Optimization of dynamic transfer limits in a power network

(Problem 4)

Coordinator : Michel Gendreau, École Polytechnique de Montréal
Industrial Partner : Hydro-Québec's Research Institute (IREQ)

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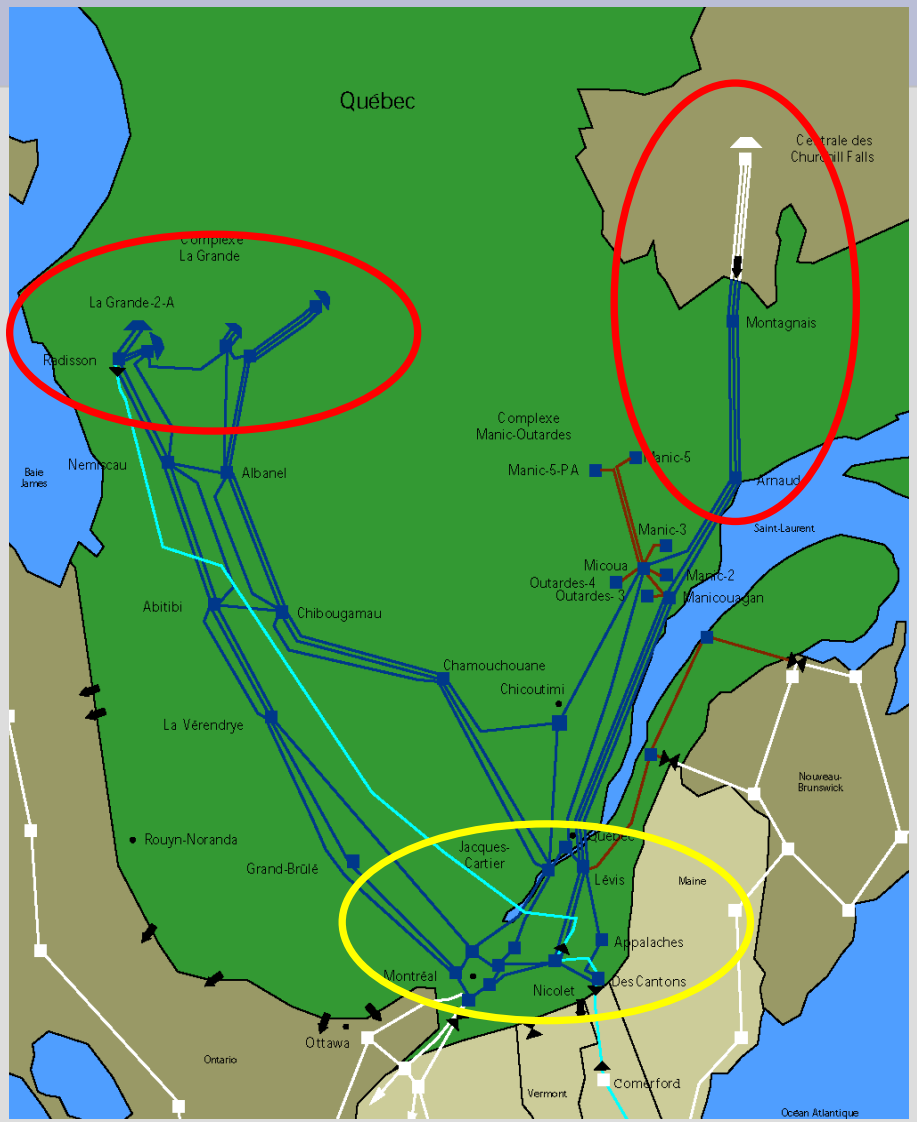
The Hydro-Quebec power network

- North : production
- South : load and export market
- 120-765 kV
- 600 lines
- 33 000 km



The problem

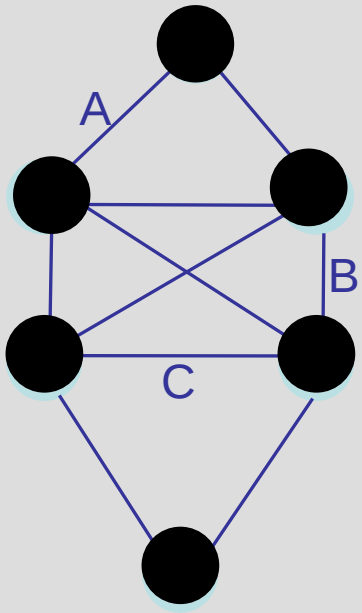
- Operator’s job is to ensure that the network is always stable
- The network can take any configuration out of a very large number
- It takes time for the operator to secure a new configuration
- Thus the operator will not consider changes with little or no impact on stability

The problem …

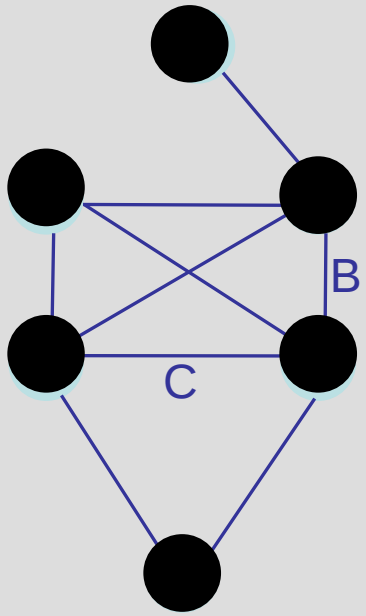
- … is to select a restricted set of changes (simple or composite) that:
  - most affect stability
  - describes as well as possible all possible configurations
  - maximizes the power flow while guaranteeing network stability

An example of network configuration

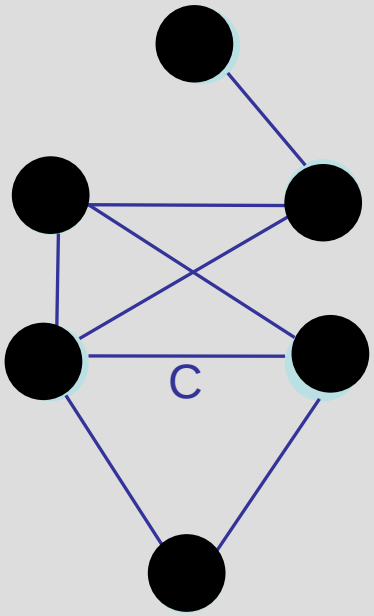
Base configuration



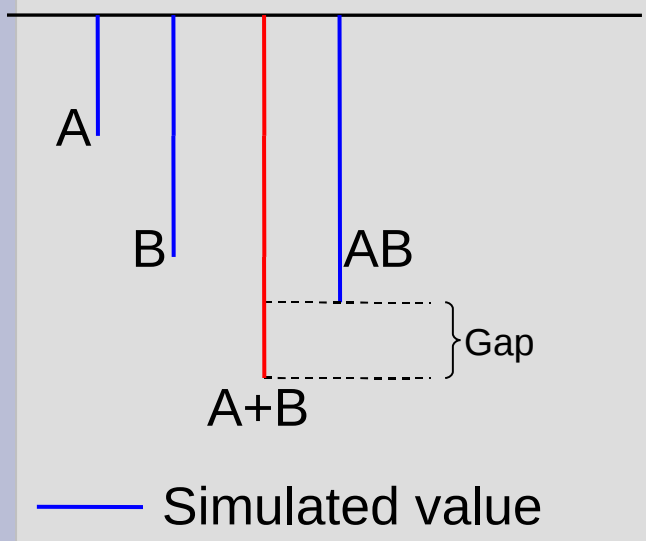
Configuration $\overline{A}$



Configuration $\overline{AB}$



An example (continued)



Configuration	Restriction (MW)
$\overline{A}$	-100
$\overline{B}$	-200
$\overline{A}+\overline{B}\sim\overline{AB}$	-300
$\overline{AB}$	-250

Goal: min $\sum$ (gaps·weight)

The ambiguity problem

Candidate	Restriction (MW)
$\overline{A}$	-100
$\overline{B}$	-175
$\overline{C}$	-150
$\overline{A}\overline{B}$	-200
$\overline{A}\overline{C}$	-225

$\overline{A}\overline{B}\overline{C}$ = ?

$\overline{A}\overline{B}$ + $\overline{C}$ = -350

$\overline{A}\overline{C}$ + $\overline{B}$ = -400

Ambiguity removal

Candidate	Restriction (MW)
$\overline{A}$	-100
$\overline{BC}$	-150
$\overline{ABC}$	-200

$\overline{ABC} = -200$

Selection of a solution approach : Tabu search

- Exact methods
  - The problem is quite large and highly combinatorial
- Heuristic methods
  - Greedy and descent methods
- Metaheuristics
  - Genetic Algorithm (weak, highly combinatorial)
  - Memetic Algorithm
  - Ant Colony (too complex, many components)
  - Particle Swarm Optimization
  - Tabu Search

Tabu search algorithm

Initialization

Choose (construct) an initial solution s_0

Set $S := S_0$, $f^* := f(S_0)$, $S^* := S_0$, $T := \varnothing$

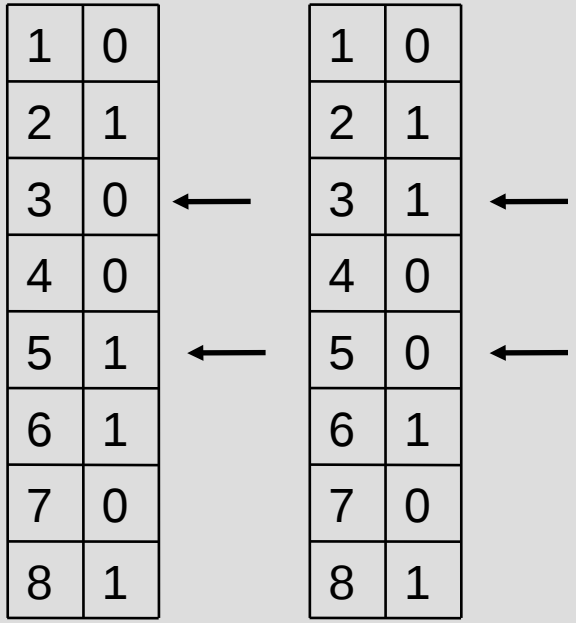
Search
While termination criterion not satisfied *do*

- $S :\in \underset{S' \in \overline{N}(S)}{\arg\max} \{f(S')\}$
- *if* $f(S) > f^*$, *then* $f^* := f(S), S^* := S;$
- *record tabu for the current move in T (delete oldest tabu if necessary)*

Neighbourhood

- Swap (50%) or adjustment (50%)

- Swap:
  - Pick one active candidate and one inactive candidate
  - Check for ambiguity
  - Evaluate objective function



Neighbourhood

- Swap (50%) or adjustment (50%)

- Adjustment:
  - Pick one active candidate randomly
  - Check for ambiguity
  - Try *Restriction* + *g* and *Restriction - g*

Conclusion

- During this week, we :
  - Analyzed a problem
  - Modeled it as an optimization problem
  - Reviewed several methods to try solving it
  - Started to implement a metaheuristic